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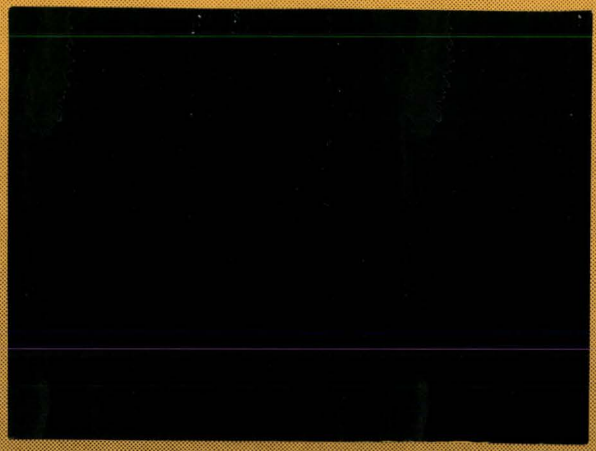

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Forest Pest Management
Denver, Colorado

BIOLOGICAL EVALUATION

R2-90-1

Douglas-fir Beetle Infestation Following the Clover Mist Fire on the Clarks Fork Ranger District, Shoshone National Forest, Wyoming

1990

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ABSTRACT

In 1989, Douglas-fir beetle (DFB), Dendroctonus pseudotsugae Hopkins, was detected on the Clarks Fork Ranger District in large-diameter Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco, trees blackened by the 1988 Clover Mist Fire. At Cathedral Cliffs and Squaw Creek, respectively, 22% and 32% of charred Douglas-firs greater than 10 in. DBH were infested; approximately 9 and 16 Douglas-fir trees per acre were infested, respectively. Although half the bark samples (6 in. by 6 in.) from infested trees contained no DFB brood, average brood production was high -- 9 and 7 callow adults per sample, respectively, at Cathedral Cliffs and Squaw Creek.

Approximately 30-40% of large-diameter Douglas-fir trees in adjacent green stands had some bole scorch. Although not infested by DFB in 1989, many are likely to be attacked in 1990. These weakened trees represent approximately 13-17 trees per acre at Cathedral Cliffs and 21-28 trees per acre at Squaw Creek. Conditions are favorable for an increase in the DFB population and an outbreak may be imminent. High numbers of DFB, which develop from the fire-damaged trees, may overcome the defenses of healthy, green trees as well. Management alternatives to reduce the impact of DFB infestation are discussed.

INTRODUCTION

During August 1988, the catastrophic Clover-Mist Fire entered the Shoshone National Forest in Wyoming from Yellowstone National Park, sweeping across much of the North Absaroka Wilderness and into the Clarks Fork Ranger District, generally south of U.S. Highway 212 and Forest Route 100. The hot, wind-driven fire destroyed extensive acreages of mixed conifer stands, composed predominately of lodgepole pine (Pinus contorta Dougl. ex Loud.), Engelmann spruce (Picea engelmannii Perry ex Englem.), and Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco).

During site visits to salvage areas in July, August, and September of 1989, entomologists determined that the Douglas-fir beetle, Dendroctonus pseudotsugae Hopkins (Coleoptera: Scolytidae), was present in large-diameter, fire-scorched Douglas-fir trees. The thick bark of the Douglas-fir protected the phloem from excessive drying even in completely blackened trees, providing suitable habitat for the establishment of DFB brood. The purpose of this evaluation was to assess the population levels of DFB at Cathedral Cliffs and Squaw Creek and determine the potential for spread to adjacent green stands.

METHODS

On November 7-8, 1989, variable plots (10 BAF) were surveyed in burned sites and adjacent green stands at Cathedral Cliffs and Squaw Creek. Plots were located approximately 5 chains apart in stands composed predominately of Douglas-fir and Engelmann spruce. For trees at least 10 in. DBH, the following information was recorded: species, DBH, and condition (i.e., green, scorched, or dead from other causes). Additionally, scorch height, crown height, percent of crown burned, and crown color (green or burned) was estimated for Douglas-fir sample trees.

Bark samples (6 in. by 6 in.) were removed at a height of 5-7 ft. from the north and south sides of Douglas-fir trees apparently infested by DFB. For each bark section, number of DFB brood by life stage was tallied.

For each plot and stand, trees per acre was estimated using a conversion factor table and means were calculated for DBH, scorch height, larvae per sample, and callow adults per sample for Douglas-fir. For a data subset containing only plots with infested trees, a nested analysis of variance procedure was performed using SPSS/PC+ for DBH by plot within infestation category (not infested vs. infested by DFB). Because scorch height data were non-homogeneous and non-normal, one factor analyses of variance by permutation test were performed on scorch height by infestation category for plots containing trees infested by DFB at each location.

RESULTS

Trees per acre and number of Douglas-fir trees by infestation category are summarized in Table 1. DFB attacked 22% and 32% of fire-damaged Douglas-firs 10 in. DBH or greater at Cathedral Cliffs and Squaw Creek, respectively. No attacks were detected in green stands. Approximately 9 and 16 Douglas-fir trees per acre ($\geq$ 10 in. DBH) were infested by DFB in burned stands at Cathedral Cliffs and Squaw Creek, respectively.

Mean DBH of Douglas-fir trees ($\geq$ 10 in. DBH) uninfested and infested by DFB are summarized in Table 2. For plots containing trees infested by DFB, DBH was significantly different ($\alpha = 0.05$) between infested and uninfested trees ($F = 5.28$; $df = 1$; $P = 0.044$). This indicates that DFB were preferentially selecting the largest diameter trees for attack.

Tree condition (green, scorched, or otherwise dead), crown color (green or burned) and mean scorch height are summarized in Table 3. All but one of the trees infested by DFB were completely blackened. In this case, the tree had lost 60% of the crown to fire. For plots with DFB-infested trees, there was no significant difference ($\alpha = 0.05$) between scorch height of infested and uninfested trees (Cathedral Cliffs: $P = 0.21$; Squaw Creek: $P = 0.115$). Virtually every tree in the burned areas sustained 100% crown damage, whereas little to none of the crowns in green stands were burned.

Approximately 30-40% of Douglas-fir trees in the green stands had some bole scorch.

Brood production of DFB in bark samples is summarized in Table 4. Few larvae and no pupae were detected. Densities of callow adults, the usual overwintering stage of the DFB (Furniss and Orr 1978), was quite variable. Approximately half the bark samples contained no DFB brood, but individual samples that were traversed by a gallery contained many callow adults. Apparently, brood galleries were widely spaced in many trees. Mean number of beetles per sample was greater on the north side of trees at Cathedral Cliffs and the south side at Squaw Creek. Overall brood production averaged 9 and 7 beetles per sample, respectively, at Cathedral Cliffs and Squaw Creek. This suggests that high population levels are present (Chansler 1968; Schmitz and Rudinsky 1968).

DISCUSSION

Large-diameter ($\geq$ 14 in. DBH), blackened Douglas-fir trees support a high population of DFB on the Clarks Fork Ranger District. Adult beetles are expected to emerge and attack new host material in spring and early summer 1990. At that time, blackened trees are unlikely to remain suitable hosts because of drying and deterioration of the phloem. However, large-diameter scorched trees with green crowns are likely to be highly attractive because of their weakened condition and healthy phloem. Healthy green trees are less susceptible to attack, but can be overcome by large numbers of beetles; they are likely to be attacked once scorched trees have been occupied and if DFB populations remain high.

An abundance of suitable host material is present in stands adjacent to the blackened stands. Assuming 30-40% of Douglas-fir trees are scorched in green stands, 13-17 trees per acre at Cathedral Cliffs and 21-28 trees per acre at Squaw Creek are estimated to provide good habitat for DFB. These figures represent trees in the large diameter classes ($\geq$ 10 in. DBH), which are preferred by DFB. Thus, there are more weakened, large-diameter trees available for attack in 1990 than there are currently (1989) infested trees in adjacent blackened stands. The largest diameter scorched trees are likely to be attacked first. Provided brood production and survival is good, existing stand conditions set the stage for a potential population increase beyond the present level. Forest Pest Management personnel need to reevaluate stands in 1990 to determine DFB population levels and trends and assess amount of damage.

ALTERNATIVES

Several methods are available to reduce populations of DFB and the resultant tree mortality. These pest management strategies may focus on the reduction of infested material, reduction of susceptible host material, or prevention of new attacks. The decision to use a particular method should be predicated on considerations of stand conditions, location, management objectives, economic factors, and other pertinent variables.

Alternative 1: Salvage Harvesting - Fell infested, scorched, and dead trees and remove them from the site for mill processing prior to adult DFB emergence. Stands with the highest percentages of large-diameter Douglas-fir should be given priority.

Alternative 2: Tree Baits - Commercially-available DFB tree baits containing attractant semiochemicals (aggregation pheromone) can be used to concentrate beetles in trees that can be subsequently harvested. Ideal sites for placement of baits would be fire-scorched Douglas-fir trees in and around salvage operations. Baits are deployed just prior to beetle flight (May) and baited trees must be felled and removed or destroyed prior to the next adult emergence period (i.e., within one year).

Alternative 3: Mechanical Control - Fell and buck infested and susceptible (fire-scorched) Douglas-fir trees and treat them by burning, peeling the bark, or chipping the logs.

Alternative 4: Silvicultural Treatment - To reduce susceptibility in green stands, basal area should be reduced below 80% of normal stocking (Furniss et al. 1981.). Mature and overmature stands of Douglas-fir can be harvested. Younger stands should be thinned periodically to improve vigor and reduce moisture stress.

Alternative 5: Protection of High Value Trees - Prior to beetle flight in early spring (April), the boles of valuable trees can be sprayed with carbaryl to prevent DFB attack. This method would be appropriate for use in and around campgrounds and private homes. Efficacy for protection of Douglas-fir needs to be demonstrated by a test prior to operational usage.

Alternative 6: Repellents - A granular controlled-release formulation of the DFB antiaggregative pheromone, 3-methyl-2-cyclohexen-1-one (MCH), can be broadcast or aerially applied to stands where protection is desired. The method is most suited for high value and inaccessible stands. This alternative currently requires an experimental use permit; registration of the material

with EPA is not yet completed. The results of this evaluation suggest that the DFB population density and stand characteristics are too variable for this area to be suitable for aerial pilot testing; however, testing of MCH bubble caps may be worthwhile. Bubble caps can be stapled to individual tree trunks.

Alternative 7: Do Nothing - Accept tree mortality caused by DFB as a natural phenomenon where control cannot be effected or is not desired. This may be the only viable alternative for inaccessible stands and areas designated as wilderness.

RECOMMENDATION

For stands, sites, or salvage sale areas that cannot be harvested prior to spring 1990, alternative 2 should be considered as a supplement to Alternative 1.

Alternative 3 may be considered for valuable stands or sites that are near infested stands.

Alternative 4 should be considered for long-range management plans to increase the health of forest stands to reduce their susceptibility to DFB attack.

Alternative 7 may be selected of necessity in much of the Clarks Fork Ranger District because of the extensive areas of wilderness affected by the Clover Mist Fire, the presence of inaccessible sites, the concern for visual and erosive impacts of harvesting options, and the constraints on time and manpower available to treat damaged sites.

Land managers need to develop site-specific plans to manage stands to reduce the impact of DFB where feasible. Alternatives should be carefully weighed in relation to site-specific characteristics. Forest Pest Management personnel should reassess DFB population levels and damage in 1990 following beetle flight to determine the need for further control measures.

District and Forest personnel are complimented for their early recognition of conditions suitable for development of pest problems and the timely salvaging completed thus far.

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Table 1. Trees per acre of variable plots and trees infested by Douglas-fir beetle

Location	Plot	Trees per Acre[a]			No. of Douglas-fir Trees[b]	
		All spp.	Douglas-fir	Infested DF	Uninfested	Infested
Cathedral Cliffs						
Green Stand	1	28.82	28.82	0.00	10	0
	2	80.16	19.71	0.00	3	0
	3	115.21	17.71	0.00	2	0
	4	40.05	0.00	0.00	0	0
	5	153.07	153.07	0.00	10	0
	Total				25	0
	$(\bar{x})$	83.45	43.85	0.00		
	(SD)	51.80	61.93	0.00		
Burned Stand	6	52.21	52.21	16.35	5	3
	7	53.47	53.47	0.00	8	0
	8	17.96	17.96	6.23	1	2
	9	103.67	87.31	9.72	9	2
	10	45.22	11.06	2.61	2	1
	11	45.21	12.77	0.00	3	0
	Total				28	8
	$(\bar{x})$	52.96	39.13	8.73		
	(SD)	27.99	30.43	5.85		
All	$(\bar{x})$	66.82	41.28	2.91		
	(SD)	41.46	44.76	5.27		
Squaw Creek						
Green Stand	12	85.90	72.02	0.00	11	0
	13	125.27	125.27	0.00	15	0
	14	42.33	39.51	0.00	7	0
	15	68.84	46.23	0.00	6	0
	Total				39	0
	$(\bar{x})$	80.59	70.76	0.00		
	(SD)	34.77	38.95	0.00		
Burned Stand	16	58.75	51.12	5.92	6	3
	17	75.76	75.76	26.28	5	4
	18	58.50	58.50	0.00	4	0
	Total				15	7
	$(\bar{x})$	64.34	61.79	16.10		
	(SD)	9.89	12.65	14.40		
All	$(\bar{x})$	73.62	66.92	4.03		
	(SD)	26.69	28.89	9.23		

[a] Calculated from BAF 10 conversion factor table for variable plots using trees $\geq$ 10 inches DBH.

[b] For trees $\geq$ 10 inches DBH.

Table 2. Mean diameters of Douglas-fir trees uninfested and infested by Douglas-fir beetle in variable plots.

Location	Plot	DBH (in.) of Douglas-fir (x ± SD)	
		Uninfested	Infested
Cathedral Cliffs			
Green Stand	1	25.9 ± 4.7	--
	2	18.0 ± 5.3	--
	3	14.0 ± 1.4	--
	4	--	--
	5	10.7 ± 1.4	--
	All	17.9 ± 7.8	--
Burned Stand	6	17.2 ± 5.9	18.0 ± 1.7
	7	18.1 ± 4.9	--
	8	12.0 ± 0.0	24.0 ± 2.8
	9	15.8 ± 4.8	19.0 ± 1.4
	10	20.5 ± 2.1	26.0 ± 0.0
	11	21.7 ± 5.5	--
	All	17.5 ± 5.0	20.8 ± 3.6
Squaw Creek			
Green Stand	12	16.0 ± 2.8	--
	13	16.7 ± 5.3	--
	14	18.4 ± 3.9	--
	15	17.2 ± 5.7	--
	All	16.9 ± 4.5	--
Burned Stand	16	17.2 ± 6.7	30.7 ± 4.5
	17	13.6 ± 2.6	16.5 ± 2.1
	18	11.0 ± 2.0	--
	All	14.3 ± 5.0	22.6 ± 8.1

[a]For trees ≥ 10 inches DBH.

Table 3. Tree condition, crown color, and mean scorch height of Douglas-fir trees in variable plots

Location	Plot	Tree Condition			Crown Color		Mean Scorch Height (ft.)					
							All Douglas-fir		Uninfested DF		Infested DF	
		No. Green	No. Scorched	No. Other Dead	No. Green	No. Burned	$\bar{X} \pm$ SD	N	$\bar{X} \pm$ SD	N	$\bar{X} \pm$ SD	N
Cathedral Cliffs												
Green Stand	1	8	2	0	10	0	2.1 ± 5.1	10	2.1 ± 5.1	10	--	0
	2	3	0	0	3	0	0.0 ± 0.0	3	0.0 ± 0.0	3	--	0
	3	2	0	0	2	0	0.0 ± 0.0	2	0.0 ± 0.0	2	--	0
	4	0	0	0	0	0	--	0	--	0	--	0
	5	3	6	1	10	0	0.7 ± 1.2	10	0.7 ± 1.2	10	--	0
	All	16	8	1	25	0	1.1 ± 3.3	25	1.1 ± 3.3	25	--	0
Burned Stand	6	0	8	0	1	7	23.8 ± 25.2	8	11.0 ± 5.4	5	45.0 ± 32.8	3
	7	0	8	0	8	0	85.4 ± 19.1	8	85.4 ± 19.1	8	--	0
	8	0	3	0	1	2	63.7 ± 10.3	3	55.0 ± 0.0	1	68.0 ± 9.9	2
	9	0	11	0	9	2	65.5 ± 19.4	11	64.0 ± 21.4	9	72.5 ± 3.5	2
	10	0	3	0	2	1	78.3 ± 32.5	3	62.5 ± 24.7	2	110.0 ± 0.0	1
	11	0	3	0	3	0	87.0 ± 19.2	3	87.0 ± 19.2	3	--	0
	All	0	36	0	24	12	63.4 ± 30.6	36	62.7 ± 31.6	28	65.8 ± 28.3	8
Squaw Creek												
Green Stand	12	5	6	0	11	0	2.9 ± 3.3	11	2.9 ± 3.3	11	--	0
	13	12	3	0	15	0	0.6 ± 1.3	15	0.6 ± 1.3	15	--	0
	14	1	6	0	6	1	12.0 ± 23.5	7	12.0 ± 23.5	7	--	0
	15	4	2	0	6	0	1.3 ± 2.8	6	1.3 ± 2.8	6	--	0
	All	22	17	0	38	1	3.4 ± 10.4	39	3.4 ± 10.4	39	--	0
Burned Stand	16	0	9	0	0	9	51.8 ± 20.4	9	44.3 ± 21.4	6	66.7 ± 5.8	3
	17	0	9	0	0	9	51.1 ± 6.5	9	51.0 ± 6.5	5	51.2 ± 7.5	4
	18	0	4	0	0	4	42.5 ± 6.4	4	42.5 ± 6.4	4	--	0
	All	0	22	0	0	22	49.8 ± 13.9	22	46.1 ± 14.1	15	57.8 ± 10.4	7

Table 4. Brood production in bark samples of trees infested by Douglas-fir beetle[a]

Location	Sample direction	Mean no. of larvae per 6" x 6" sample		Mean no. of callow[b] adults per 6" x 6" sample	
		$\bar{x} \pm$ SD	N	$\bar{x} \pm$ SD	N
Cathedral Cliffs	North	1.9 ± 4.9	8	15.6 ± 20.9	8
	South	0.4 ± 0.7	8	2.8 ± 7.8	8
	All	1.1 ± 3.5	16	9.2 ± 16.6	16
Squaw Creek	North	0.1 ± 0.4	7	4.8 ± 6.8	7
	South	0.3 ± 0.5	7	9.8 ± 10.9	7
	All	0.2 ± 0.4	14	7.4 ± 9.1	14
Total Population (All locations)	North	1.1 ± 3.6	15	10.6 ± 16.4	15
	South	0.3 ± 0.6	15	6.1 ± 9.7	15
	All	0.7 ± 2.6	30	8.3 ± 13.4	30

[a] All infested trees were located in burned stands.

[b] Approximately 1/2 the samples contained no callow adults.